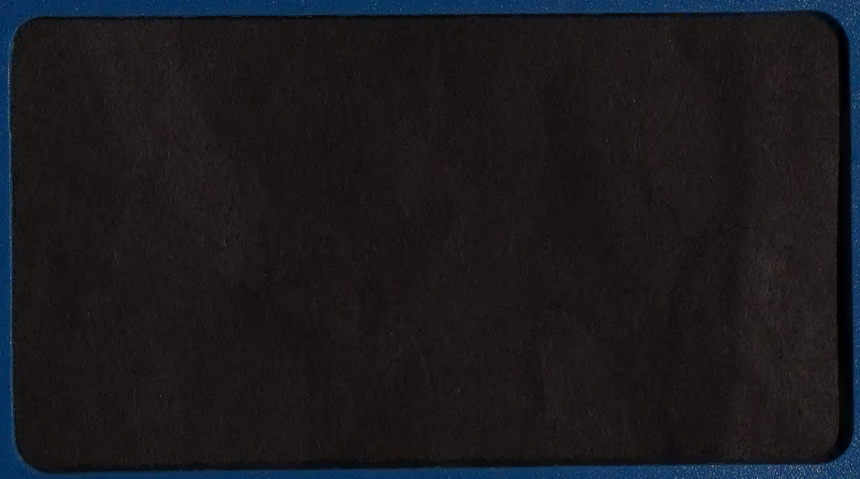

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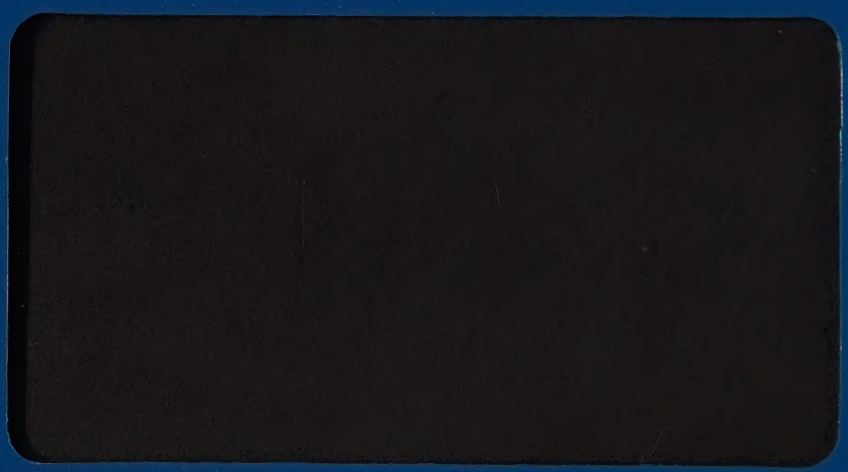
Signal Processing Systems

MP MASTER

MA29851



GPIB INTERFACE MANUAL

MODEL GPD550A
FAST SPECTRUM ANALYZER

Scientific-Atlanta, Inc.
Signal Processing Systems

411354 July 1991 Rev A

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SECTION 1

SPECIFICATION

1.1 INTRODUCTION

This document is meant as an aid in the development of user software that allows the GPD550A Fast Spectrum Analyzer to be remotely controlled and queried using a standard interface system. The interface implemented conforms to the specifications contained in the IEEE Standard Digital Interface for Programmable Instrumentation (ANSI/IEEE Std 488-1978), commonly referred to as the General Purpose Interface Bus (GPIB). It also complies with the IEEE Recommended Practice for Code and Format Conventions Std 728-1982.

This manual describes GPIB operational elements only in relation to communication between the Spectrum Analyzer and the Controller by way of the bus. For complete information regarding GPIB electrical, mechanical, and functional aspects, refer to ANSI/IEEE Std 488-1989, which is published by:

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street
New York, New York 10017

Messages originating from a remote controlling device and transmitted over the GPIB provide the following interface capabilities:

1. Set the GPD550A's mode of operation by controlling designated front panel switches.

2. Query the GPD550A front panel switch settings and cursor measurement.

3. Read real time and averaged spectrum data in both 12 and 8-bit formats.

4. Read processing status information.

All the GPD550A's Unit 1 front panel functions are controllable through the GPIB interface, except for Power. On Unit 3, the Waterfall Hold, RT/BOTH/AVGR switch and the cursor which selects the bin from which the amplitude is displayed, can be controlled remotely. More information regarding the structure and format of the commands and queries are explained in Section 3, "Controlling Front Panel Over the GPIB." A listing of the command headers and arguments, along with concise descriptions, is also provided in Section 3.

1.2 IEEE INTERFACE CAPABILITIES

The total interface-function capabilities of an instrument on the GPIB, in terms of capability identification codes, is identified in ANSI/IEEE Std 488-1978. The specific interface-function capabilities implemented in the GPD550A are listed below.

SH 1	Source Handshake	Complete capability
AH 1	Acceptor Handshake	Complete capability
T2	Basic Talker	Responds to Serial Poll
L2	Basic Listener	
SR1	Service Request	Complete capability
RL1	Remote-Local	Complete capability
PP0	Parallel Poll	Does not respond to Parallel Poll
DC1	Device Clear	Complete capability
DT0	Device Trigger	Does not have Device Trigger Capability

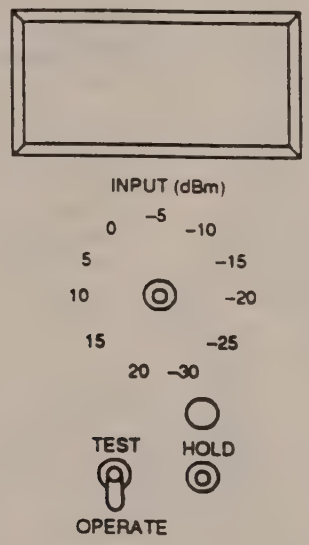
SECTION 2

CONTROLS, CONNECTORS, AND INDICATORS

2.1 FRONT PANEL CONTROL

This section briefly summarizes the operation of the GPD550A Unit 1 and selected switches of Unit 3. The following switches can be remotely controlled through the GPIB interface unless specifically stated otherwise.

2.1.1 INPUT GROUP



INPUT (dBm) Gain/Attenuation Selector

Selects Input gain (0 dBm to 30 dBm) or attenuation (0 dBm to 20 dBm). This gain or attenuation is applied to the input signal in order to normalize the amplitude of the signal to the A/D converter.

OPERATE/TEST Selector

Selects the input signal or connects the internal test signal to the input. The input remains terminated, but a test signal is substituted for the input. The test signal is a 480 KHz pulse train such that all harmonics of this signal are present.

HOLD Pushbutton

Operates load control to prevent update of input memory. LED is illuminated when in HOLD.

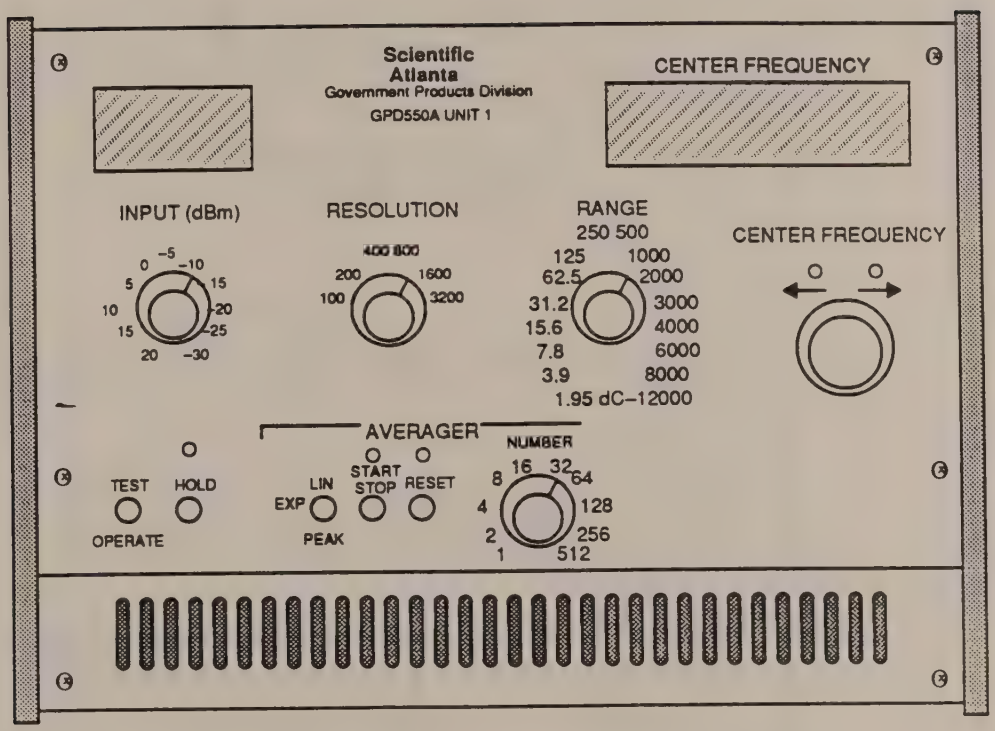
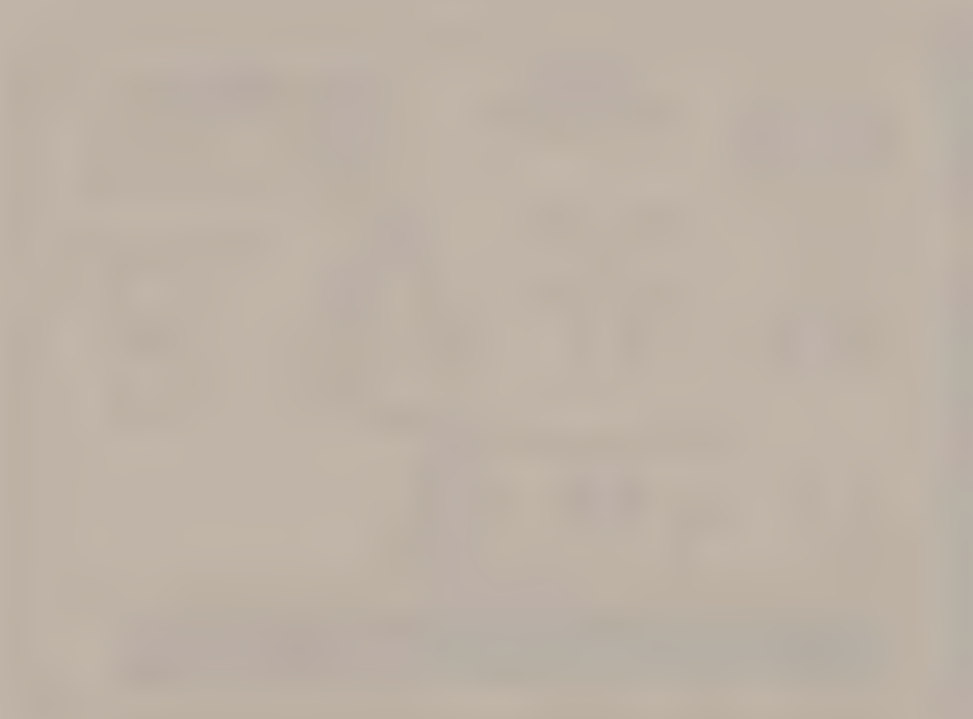


Figure 2.1. GPD550A Unit 1 Front Panel



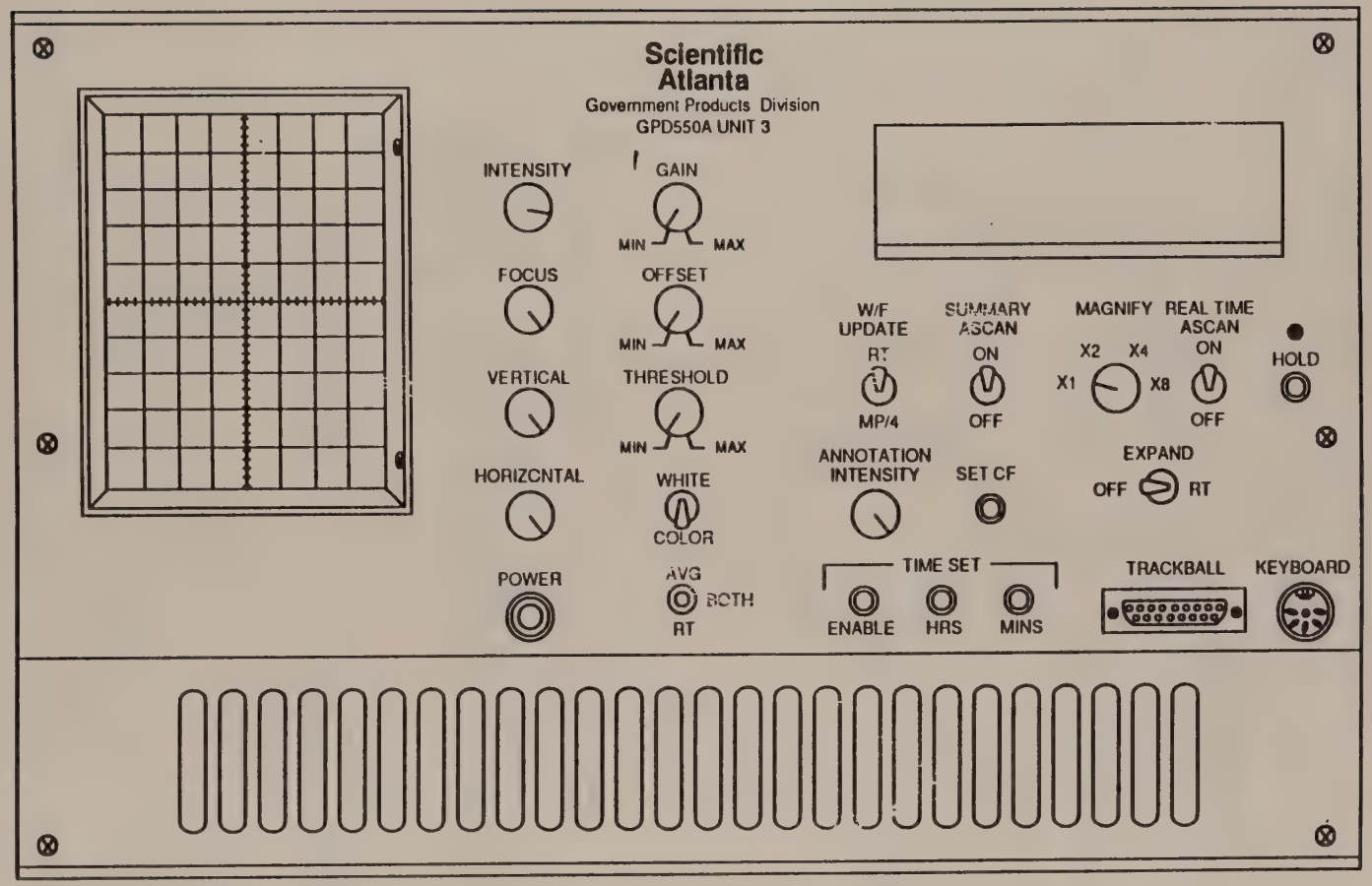
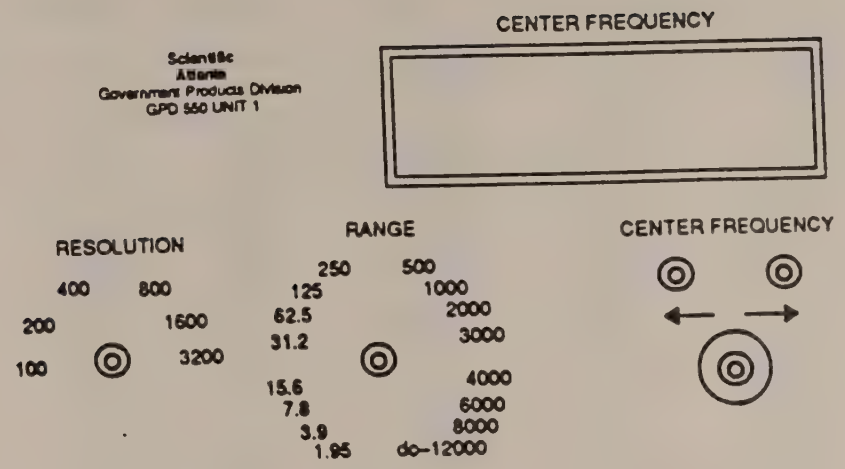


Figure 2.2. GPD550A Unit 3 Front Panel

2.1.2 ANALYSIS GROUP



RESOLUTION Selector

Determines the number of cells to be displayed and the transform size. The number of cells displayed is equal to the resolution and the transform size is equal to the resolution times 1.28.

Transform Size	Resolution (Number of Cells Displayed)
4096	3200
2048	1600
1024	800
512	400
256	200
128	100

Table 2-1. Cell Size in Hz Given Front Panel Range and Resolution

Range (Hz)	Resolution (Number of Cells) 100	200	400	800	1600	3200
12M	120K	60K	30K	15K	7500	3750
8M	80K	40K	20K	10K	5000	2500
6M	60K	30K	15K	7500	3750	1875
4M	40K	20K	10K	5000	2500	1250
3M	30K	15K	7500	3750	1875	937.5
2M	20K	10K	5000	2500	1250	625
1M	10K	5000	2500	1250	625	312.5
500K	5000	2500	1250	625	312.5	156.25
250K	2500	1250	625	312.5	156.5	78.13
125K	1250	625	312.5	156.5	78.13	39.06
62.5K	625	312	156.5	78.13	39.06	19.53
31.2K	312	156	78	39	19.5	9.75
15.6K	156	78	39	19.5	9.75	4.875
7.8K	78	39	19.5	9.75	4.88	2.48
3.9K	39	19.5	9.75	4.88	2.44	1.22
1.95K	19.5	9.75	4.88	2.44	1.22	.61

RANGE (KHz) Selector

Selects the analysis frequency range from 1.95 KHz to 12 MHz. Additional ranges may be selected remotely via the GPIB connector on the rear panel. The selected range is in baseband mode and the Baseband bandwidth is from 0 Hz to the indicated value on the front panel when the Center Frequency selector is set to Bandwidth/2.

The following table defines the available GPD550A ranges. Front Panel selectable ranges are marked with the character '*'. All ranges are GPIB accessible.

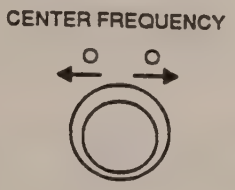
12 MHz*	8 MHz*	4.8 MHz
6 MHz*	4 MHz*	2.4 MHz
3 MHz*	2 MHz*	1.2 MHz
1.5 MHz	1 MHz*	.6 MHz
.75 MHz	.5 MHz*	300 KHz
375 KHz	250 KHz*	150 KHz
187.5 KHz	125 KHz*	75 KHz
93.75 KHz	62.5 KHz*	37.5 KHz
46.875 KHz	31.25 KHz*	18.75 KHz
23.4375 KHz	15.625 KHz*	9.375 KHz
11.71875 KHz	7.8125 KHz*	4.6875 KHz
5.859375 KHz	3.90625 KHz*	
2.9296875 KHz	1.953125 KHz*	

CENTER FREQUENCY (Hz) Knob

The CENTER FREQUENCY (Hz) knob selects values from dc to 12 MHz, except when the Range switch is dc-12 MHz, during which it defaults to 6 MHz.

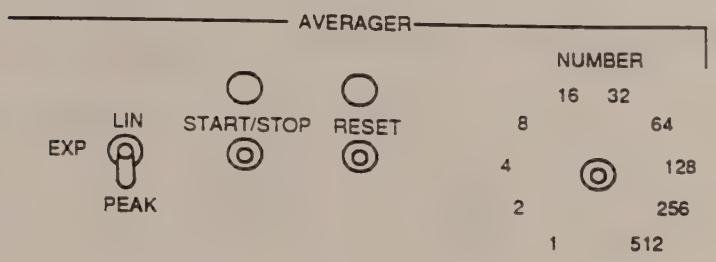
Center Frequency may be changed via the front panel in two ways:

(1) Center Frequency buttons/knob on Unit 1. The buttons allow pulse high speed operation, while the knob gives fine resolution.



(2) Set CF button on Unit 3 moves the frequency that the cursor is located at to the center of the display. Center Frequency selection is limited from dc to 12 MHz. An 'OR' will light for "Out of Range" light when any portion of the spectrum is invalid.

2.1.3 AVGR GROUP



START/STOP Pushbutton

Starts or stops the selected averaging process. In Linear mode, after the averaging is completed (LIN mode only), the averager must be reset by pushing the RESET pushbutton before it can be restarted by pushing the START/STOP pushbutton. The START/STOP LED is illuminated while the averager is running. This pushbutton is active only when the Unit 3 Waterfall Hold is enabled.

RESET Pushbutton

Stops the selected averaging process, clears the averager memory, and then lights the RESET LED. This pushbutton is active only when the Unit 3 Waterfall Hold is enabled.

AVERAGER MODE Selector

LIN Linear Averaging. Averages the number of ensembles selected and holds the results in the averager memory.

EXPO Exponential Averaging. Continuous averaging with time constant determined by the NUMBER OF AVERAGES selector.

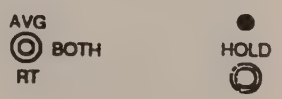
PEAK Continuous averaging with real time data compared cell-by-cell with data in the averager memory. Averager memory is updated only when the real time data is greater.

If the Averager is operating in either the EXPO or PEAK mode and the mode selector is changed to the LIN mode, the Averager will be automatically RESET before the LIN mode can start averaging. The Averager does not automatically reset if the averager is operating in the LIN mode and the mode selector is changed to either the EXPO or PEAK mode.

NUMBER OF AVERAGES Selector

Selects the number of ensembles, in binary steps from 1 to 512, to be averaged.

2.1.4 DISPLAY GROUP



The cursor and the RT/BOTH/AVGR selector subgroup are controllable over the GPIB only in remote with local lockout. When the GPD550A is in remote without local lockout,these controls remain under the front panel control. This is intended to ease the user's task of monitoring the panel display and examining the data at the same time.

CURSOR

The trackball controls the position of the cursor. The CURSOR is controlled over the GPIB when in remote and local lockout by writing the cell, or bin number. The number of bins displayed is set by the transform size detector. Querying the cursor setting will result in a reply indicating the bin number that the cursor is currently on.

RT/BOTH/AVGR

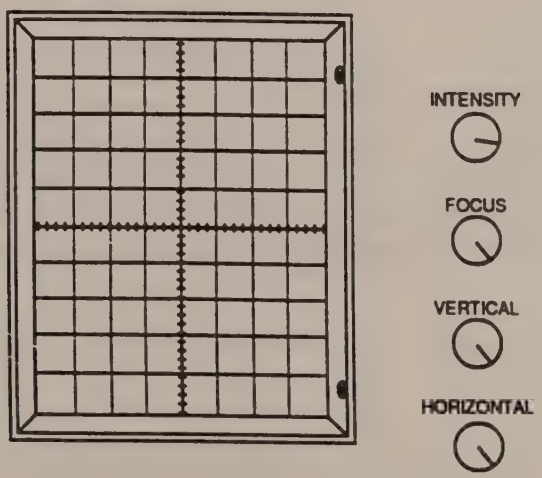
Selects RT (Real Time), BOTH (Real Time and Averager memory), or AVGR (averager memory) to be displayed. RT/BOTH/AVGR is controllable through the GPIB interface only when the GPD550A is in remote with local lockout.

WATERFALL HOLD Pushbutton

This pushbutton stops updating Waterfall memory, stops the recycle averager mode leaving the averager stopped, and allows the system to operate as an independent analyzer using the averager controls on Unit 1.

2.1.5 X-Y SCOPE CONTROLS

None of the X-Y Scope controls on Unit 3 are controllable through the GPIB.



INTENSITY

When rotated clockwise, the display screen is brightened. Conversely, when rotated counterclockwise, the screen dims.

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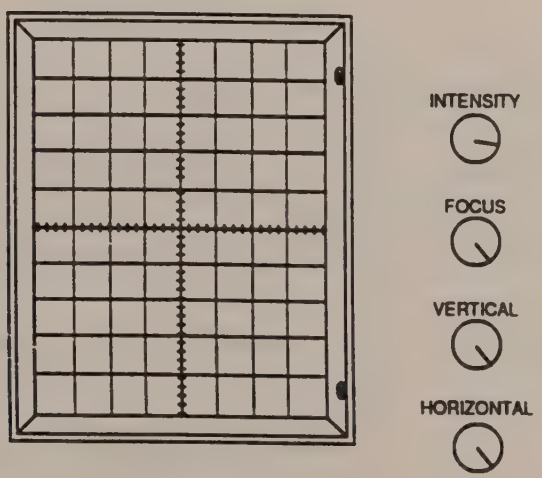

INTENSITY

When rotated clockwise, the display screen is brightened. Conversely, when rotated counterclockwise, the screen dims.

FOCUS

Focuses the display.

VERTICAL

When this knob is turned clockwise, the baseline is moved up the screen; for counterclockwise motion, the baseline is moved down.

2.2 REAR PANEL - UNIT 1

See Figure 2.3 for location of the following connector and switch.

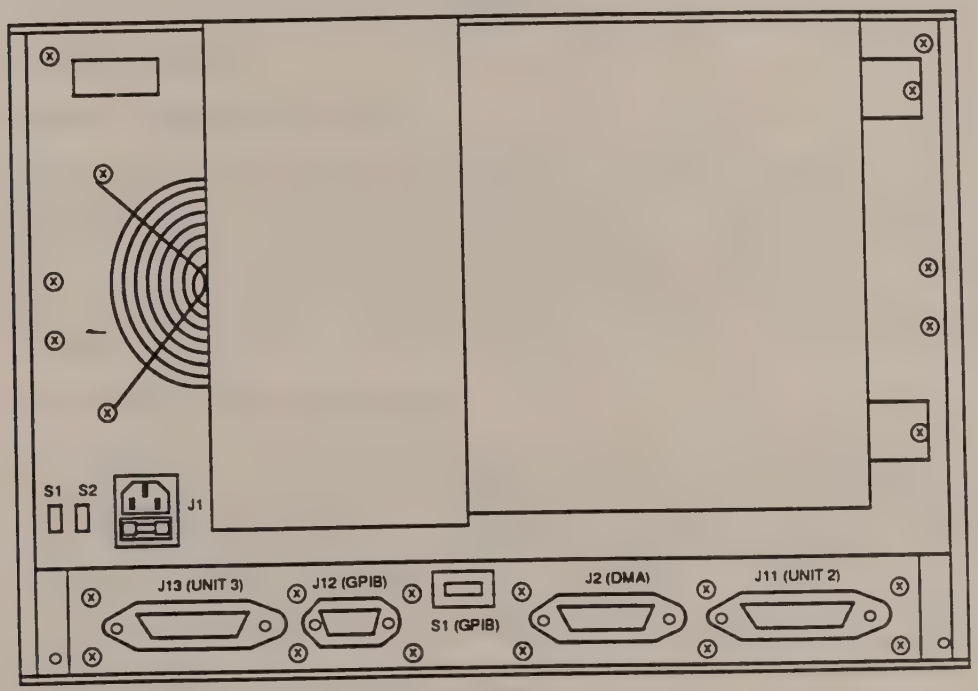

Figure 2.3. GPD550A Unit 1 Rear View

GPIB Connector- J12 (24 pins)

This connector provides the IEEE Std 488-1978 compatible electrical and mechanical connection to the GPIB.

7-Position DIP Switch - SW1

Selects the primary talk/listen address for the GPD550A. It is normally set to 5 (off, on, off, on, on) position 7 to 3. However, the primary talk/listen address can be set to any value between 0 and 31, inclusive, by simply setting the DIP switch positions 3 through 7 to the binary code corresponding to the desired address (position 7 = least significant bit). Positions 1 and 2 are unused.

For information regarding other connectors on the rear panel, refer to the GPD550A Technical Manual.

2.3 INDICATORS AND READOUT DISPLAYS

2.3.1 INPUT GROUP

SIGNAL LEVEL Indicator

Indicates the relative amplitude of the input signal. UNDR indicates a "too low" input signal. OVR indicates a "too high" input signal and that the signal exceeds the level at which the A/D converter can operate properly. The signal level can be monitored over the GPIB by reading the serial poll byte, which indicates if overload (OVR) or underload (UNDR) occurs.

GPIB FUNCTION Indicators

The GPIB indicators are placed above the Input Signal UNDR/OVR indicators. The appropriate indicators, TALK LSTN (listen), and SRQ (Serial Request), illuminate when the GPIB is performing certain operations or when the GPIB has placed the GPD550A into REM (remote) mode.

3.2.2 ANALYSIS GROUP

CENTER FREQUENCY (Hz) Display

Provides a nine-digit LED readout of the Center Frequency location.

2.3.3 DISPLAY GROUP

CURSOR FREQUENCY (Hz) and AMPLITUDE Display

Provides a nine-digit LED readout of the frequency at the cursor location, a three-digit display of the cursor amplitude, and OR (Out of Range) bar LED that lights up when any portion of the screen has an invalid display (i.e., any frequency displayed is below dc or above 12 MHz). There is

also a SR (Set Reference) bar LED that denotes the delta frequency and amplitude from a selected reference point being displayed.

2.4 AVERAGER OPERATION AND CONTROL

The function of the Averager is to increase the detectability of weak signals by canceling random noise and thereby increasing the signal-to-noise ratio. This is done by point-by-point averaging real time spectra to yield an average over time. There are three methods, or modes, of averaging available: Peak, Linear, and Exponential, and in each the number of averaged real time spectra, or the number of ensembles, has a different meaning, explained as follows.

PEAK This mode runs continuously by simply making a point by point comparison of the last averaged spectrum with the current real time spectrum. The greater point value of either becomes that point of the new averager output spectrum. The number of averager ensembles has no meaning in this mode. Peak runs every FFT cycle and does not use MP/2* (memory period/2) timing.

LINEAR This mode runs until the selected number of ensembles have been averaged, at which time the averager START light will go out. To perform another average, the RESET command must be sent to reset the averager. The method of averaging is to point by point take 1/n of the current real time spectrum, where n is the number of ensembles, and sum it over n real time spectra. The averager output is this sum. Each ensemble takes MP/2* FFT cycles to process a real time spectrum.

EXPONENTIAL This mode runs continuously point by point taking (n-1)/n of the last averaged spectrum and adding 1/n of the current real time spectrum, the sum of which is the averager output spectrum. It takes MP/2*FFT cycles to process each real time spectrum.

***MEMORY PERIOD**

$$MP = \frac{\#DISPLAY\ POINTS}{BANDWIDTH}$$

Memory Period over two (MP/2) is the time period taken by the GPD550A to completely collect a new set of time domain data to make up the number of transform points for the FFT and output this set of data in frequency domain. Memory Period is a function of range and resolution, and the averager's

update cycle is the number of FFT cycles in one MP/2. For example, if the range is 1.95 KHz and resolution is 100, given the following FFT processing times, the averager update cycle can be computed as follows:

No. Processor Cycles per MP/2:

$$\text{MP/2} = \frac{(100 \text{ pts} / 1953.125 \text{ Hz})/2}{\text{FFT Time}} = \frac{}{60\ \mu s} = 426.6$$

Since the GPD550A cannot do fractional processor cycles, there are 427 FFT cycles in one MP/2 given these settings.

Transform Size	Number of Points	FFT Time
128	100	60 µs
256	200	135 µs
512	400	300 µs
1024	800	667 µs
2048	1600	1.464 ms
4096	3200	3.195 ms

CONTROL INFORMATION

* Switching form either PEAK or EXPO modes to LIN mode while the average is running will force a reset, then the averager will restart in linear. This will also force an averager complete (discernible through GPIB).

* If the number of averages changes while the averager is running in recycle, or in linear mode, the averager memory is reset, then the averager continues but uses the new selected number of ensembles.

* When Waterfall Hold is disabled, the averager is in Peak recycle mode and the averager START/STOP and RESET push-buttons are disabled. Recycle mode is when the averager automatically resets and restarts itself each time a specific number of ensembles are averaged.

SECTION 3

CONTROLLING THE FRONT PANEL OVER THE GPIB

3.1 INTRODUCTION

This section provides information about controlling the front panel by passing messages to, and receiving messages from a Controller and the GPD550A. Messages include both device-dependent programming messages which contain device-specific information such as front panel control commands or measurement results, interface messages which manage the bus itself, performing such functions as initializing bus, addressing and unaddressing devices, and setting device modes for remote or local programming.

Device-dependent programming messages may be broken into two groups, State Changes and Status Requests. State Change messages set the GPD550A's operating parameters, such as the front panel controls, and Status Requests query the GPD550A in order to send information back to the Controller.

The procedure to send a State Change message to the GPD550A is as follows:

a. Address the Controller as a Talker.

b. Address the GPD550A as a Listener.

c. Transfer the desired Status Change message.

The procedure to request information from the GPD550A by sending a Status Request message is as follows:

a. Address the Controller as a Talker.

b. Address the GPD550A as a Listener.

c. Transfer the desired Status Request message.

d. Address the Controller as a Listener.

e. Address the GPD550A as a Talker.

f. Read the information from the GPD550A.

3.2 GPIB PARAMETER SELECTION

PRIMARY ADDRESS

The selected GPIB address establishes both the primary talk and listen addresses to the GPD550A. The default primary address of the GPD550A as shipped is 5. To alter this address, DIP switch SW1 on the GPD550A Unit 1 Rear Panel must be altered. The 7-position switch is formatted as a byte, position 7 being the least significant bit. OPEN (OFF) = 1, CLOSED (ON) = 0. Therefore, the primary talk/listen address can be set to any value between 0 and 31, inclusive, by setting the DIP switch position 3 through 7 to the binary code corresponding to the desired address. Power to the GPD550A must be cycled after any changes to the switch setting.

END-OF-MESSAGE TERMINATOR

The default end-of-message terminator for the GPD550A as shipped is set to the Line-Feed (LF) character. However, the End-or-Identify (EOI) interface signal can also be chosen by the user if so desired.

When LF (normal mode) is selected:

* Either LF or EOI is accepted as the end-of-message terminator.

* Line Feed (LF) is sent at the end of a message as the end-of-message terminator.

When EOI is selected:

* Either LF or EOI is accepted as the end-of-message terminator.

* The EOI line is asserted concurrently with the last data byte of a message sent.

The end-of-message terminator is selected by position 2 of the DIP switch on the Executive CPU card (A20) of Unit 1 of the GPD550A. OPEN (OFF) selects EOI and CLOSED (ON) selects LF as the end-of message terminator.

NOTE: Parity should be disabled on those controllers which use the eighth data bit for parity.

3.3 SYNTAX AND COMMUNICATION PROTOCOL

3.3.1 MESSAGES

Programming messages, or messages sent from the controller to the GPD550A, are broken into two classes, State Changes and Status Requests. State Change messages consist of a minimum of two ASCII switch mnemonic characters, followed by a question mark, "?". This allows the user to follow a readable command syntax similar to English. All bytes transferred over the bus are ASCII, except for spectrum data transfers and data transferred following the FR (front panel) command. This specification complies with the IEEE Recommended Practice for Code and Format Conventions Standard 728-1982.

3.3.2 MESSAGE FORMATTING

Messages are broken into four parts, a Header, an Argument, a Suffix, and a Terminator. Each of these parts may be separated by any number of Space characters, with the restriction of at least a single Space between the header and the argument. Upper and lower case characters can be used freely.

3.3.3 HEADERS

The command headers are chosen to be as understandable as possible, with the capability to be shortened to a minimum of two unambiguous characters. Any characters following the first two which are not a Space are ignored. For a query, or Status Request, a question mark is appended to the header starting with the same 2 unambiguous characters that are used for the corresponding State Change to that switch. No Space is used between Status Request header and the question mark, and any characters following the question mark will be ignored. For example,

```
RA 12 MHz       ;State Change to 12 MHz Range
ra?             ;Status Request for the Range
RANGE?          ;Status Request for the Range
```

3.3.4 ARGUMENT

With the exception of the FRont command and spectrum data transfer, the argument is sent over the GPIB data bus in ASCII. When the argument is defined as integer or real, each decimal digit will be sent over the bus most significant first. Real data is limited to the Std 728-1982 NR2 Numeric Representation, whereby a number may have a leading +, -, or no sign, any number of leading digits, a decimal point, and any number of trailing digits. Examples are:

Real Arguments: 0.0
+.1
1.
0.11111

For some of the On/Off type commands, the State Change argument is an alpha string. These strings are non-blank with only the first character having significance.

3.3.5 SUFFIX

Some of the commands with a numerical argument allow a suffix which enhances the readability of the command. In some cases the suffix has no functional meaning (dBm), while in others it applies as a unit of measure to the argument (KHz). In the first case, erroneous suffixes are ignored and in the second case, an erroneous suffix invalidates the command. If no suffix is used a default suffix is assumed. Unless specifically stated, suffixes are not permitted. There need not be a space between the argument and the suffix.

3.3.6 COMMAND SEPARATOR

Multiple commands may be sent in a single block by separating each command with a ';' and ending the block with a valid command terminator. For example,

```
ra5KHz;cf 100KHzCRLF
```

Multiple commands are all parsed before implemented, and if they are all valid commands, the changes are written to the internal front panel image at the same time. The operator needs to keep this in mind when doing some operations. For example, let the GPD550A be in operation using a resolution size of 100. If the operator sends:

```
re 800;cu 400
```

The cursor will be placed at bin 100, not 400. This is because both command changes are updated to the internal front panel image at the same time, so the cursor defaults to a bin position of 100 because the internal front panel image held a resolution of 100, therefore, 100 was the maximum legal bin. On the other hand, if these commands were sent separately, the cursor would have been placed at bin position 400.

Queries cannot be embedded in multiple command strings, nor can queries be strung together separated by semicolons.

3.3.7 MESSAGE TERMINATOR

Messages must normally be terminated by a LF (Line Feed) or CRLF (Carriage Return, Line Feed). Messages can be terminated by an EOI sent along with the last command byte if this option is chosen by the operator. (See Section 3.2 for more information on selecting EOI.) Null bytes (0x00), if received by the GPD550A, are ignored.

3.3.8 RETURNED DATA MESSAGE

All returned data following a query is sent without a header or a suffix. All data sent from the GPD550A to the controller as a result of a query conform to the Measurement Message syntax as defined in Figure 21, page 21 of IEEE Recommended Practice for Code and Format Conventions. A return message is terminated with either a "LF" or an EOI, as selected by a dip switch on the executive CPU card, with the exception of block data. Block data always has a set number of bytes, therefore, the controller does not need a message terminator to signal the end of data.

3.3.9 SPECTRUM DATA COMMANDS

The GPD550A supplies the controller with the capability to both read and write spectrum data in two formats, a full dynamic range 12-bit format and a faster, yet reduced range, 8-bit format. The data is transferred over the GPIB in Block Data Format I (page 16, Figure 13 of Std 728-1982), except that the preamble, the initial two bytes, is deleted. This data may be read from three sources: The Real Time Processor, the Averager, and from External Memory. Data may be transferred in any Remote/Local state without interrupting either system's processing status. Data transferred represents the scaled 100 representation of the actual complex data point. (For more information regarding Spectrum Data Format, refer to Section 4.) Data may be written to the External Memory only. The Spectrum data transferred over the GPIB is read directly from the GPD550A's display bus; therefore, when reading spectrum data over the GPIB, the data source must be selected on the RT/EXT/AVGR switch on Unit 3 to correspond to the data source selected by the input/output spectrum command (OS/IS command).

3.3.10 MESSAGE BUFFER

A circular buffer is used to store more than one command while commands are being processed. The buffer is sufficiently large enough (256 bytes) to hold a worst case, full front panel, Status Change.

3.3.7 MESSAGE TERMINATOR

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3.3.10 MESSAGE BUFFER

A circular buffer is used to store more than one command while commands are being processed. The buffer is sufficiently large enough (256 bytes) to hold a worst case, full front panel, Status Change.

Table 3-1. GPIB Commands

Header	Argument	Description
NOTE: The minimum Header or Argument characters required are listed in Upper Case in this table.		
AMode	Lin	Selects linear averaging mode.
	Expo	Selects exponential averaging mode.
	Peak	Selects peak averaging mode.
AMode?	none	Query for current averaging mode setting. The character L is returned for linear averaging, E for exponential averaging, and P for peak averaging.
AUxdisplay	Ext	Selects both RT and averager data to be displayed (BOTH setting).
	Avgr	Selects averaged data to be displayed on the trace.
	RT	Selects RT memory to be displayed on the trace. The Aux Display switch can be controlled remotely only when the GPD550A is in Remote and Local Lockout.
AUxdisplay?	none	Query for current Auxiliary Display mode. The character E is sent if both real time and averager data is being displayed, A if averager data is being displayed, and R if real time data is being displayed.
AVgr	Reset	Averager Reset control command, resets and stops the averager.
	Cycle	Averager Cycle control command, resets and starts the averager.
	Go	Averager Start control command, starts the averager.
	Stop	Averager Stop control command, stops the averager.
AVgr?	none	Query for averager's control status. The character R is sent if averager is reset (and stopped), G if running, S if stopped, and L if linear complete and stopped.

NUmber	positive	Selects the Number of Averages. Must correspond to an actual front panel setting, or an invalid message error is generated.
NUmber?	none	Query for current Number of Averages. ASCII digits are sent integer format, most significant digit first.
OPerate/Test	Operate Test	Selects operate mode (uses input signal). Selects test mode (uses internal test signal).
Operate/Test?	none	Query for current setting for the source of signal. The character O is returned if set to Operate, and the character T is returned if set to Test signal.
RAnge	positive integer or real (+suffix)	Selects a frequency range setting. Suffixes of Hz, KHz, MHz, K, and M will be recognized. If no suffix is received, Hz is assumed. After the ASCII digits are received, the argument will be converted to integer Hz. When converting to Hz, any fraction remaining afterwards will be truncated. Ranges received will default to the nearest valid range. See Appendix C for a list of all the available ranges.
RAnge?	none	Query for current frequency range. ASCII digits sent are integer Hz.
REsolution	positive integer	Selects the Resolution Size. Value must correspond to one of the settings on the front panel.
REsolution?	none	Query for current Resolution Size. Value sent back is an ASCII representation of the integer setting as it appears on the front panel.
WFhold	E D	Enables Waterfall Hold on the Unit 3. Disables Waterfall Hold on the Unit 3.
WFhold?	none	Query for current value of the Waterfall Hold switch. The character E is returned if Hold is on, D otherwise.

3.5 SPECIAL PROGRAMMING GPIB MESSAGES

Table 3-2. Special Programming Messages

Header	Argument	Description
Error?	none	Query for the last invalid message received. Performing this query will clear the invalid message buffer. If multiple invalid messages are received before performing this query, the first received will be returned. If no valid messages have been received, "LF" will be returned.
FRont	#<32 bytes block data>	Represents complete coded front panel image in Block data format I (pg 16, Figure 13, of Std 720-1982). Each switch is encoded into a single byte. Exactly 32 bytes are read following the '#' as block data. This is a special use programming command and is intended to be typed in at the keyboard. The '#' is a reserved character and is used only by this command it signals the start of a new front panel image. No message terminator is sent following the block data. (For more information regarding "FR" Command Format, refer to Appendix B.)
FRont?	none	Exactly 32 bytes integer block data are sent in reply. Represents complete coded front panel. No message terminator is sent following the block data.
OSpectrum	LA	This command initiates a spectrum data transfer from the GPD550A Averager to the Controller. Immediately following the command, the GPD550A is addressed as a talker and the spectrum is read by the controller in integer block format with the data represented in 12-bit long format.
	LR	Same as above, except that data comes from Real Time memory.
	SA	This command does exactly the same operation as LA, except the spectrum is sent over the GPIB in integer block format with the data represented in 8-bit (short) format.
	SR	Same as above, except that data comes from Real Time memory.

SMask	positive integer	This command sets the Service Request Mask. Value must be less than 64 since only the lower six bits are used for the Service Request Mask.
SMask?	none	Query for current Service Request Mask. Value is sent back in ASCII integer format, most significant digit first.
TEst	"<5 ASCII bytes>	This command serves as a means of checking the functionality of the GPIB. The 5 bytes do not cause any 550A Status Changes. The bytes must be alphanumeric and enclosed by double quotes.
TEst?	none	Query for the 5 test bytes previously sent using the command TEst. If the 550A has yet to receive the TEst command, the string "RESET" will be returned.

3.6 ERROR CONDITIONS

a. Address changes mid-message will terminate and invalidate the message. An invalid message error will be signaled, causing a Serial Poll if the Command Error bit in the Service Request Mask is unmasked and Serial Poll is enabled.

b. Incomplete messages will be ignored and will be signaled by an invalid message error.

c. Erroneous message parameters will be ignored and will be signaled by an invalid message error.

d. A message buffer overflow will be signaled by an invalid message error. Only complete messages in the buffer will be processed.

e. All State Change commands are ignored in Local control.

3.7 LOCAL/REMOTE OPERATING STATES

Following are descriptions of the four operating states of the GPD550A: Local, Local With Lockout, Remote, Remote With Lockout.

LOCAL STATE (LOCS)

In this state, instrument parameters are set and changed manually by the operator using front panel controls. IEEE-488 interface messages and queries can successfully be sent by the controller, but status change commands are ignored while in LOCS. There are 2 ways a device may return to LOCS from remote control: lowering of the REN line by the controller, and issuance of a go to local (GTL) command by the controller when the GPD550A has been addressed as a listener.

LOCAL WITH LOCKOUT (LWLS)

The GPD550A operates the same in LWLS as it does in Local State. The interface will enter Remote With Lockout State (RWLS) when it receives its listen address (MLA).

REMOTE STATUS (REMS)

In REMS, the controller has control over the GPD550A's operating parameters via commands addressed to it over the GPIB. The only exceptions are to certain display controls, such as the CURSOR, Auxiliary Display (RT/EXT/AVGR), and SET REF, these remain under front panel control. All other front panel control switch changes are ignored while in the Remote State. Sending GO TO LOCAL (GTL) messages from the controller will cause the GPD550A to return to LOCS. All other front panel control switch changes are ignored while in the Remote State. The controller can place the GPD550A into a Remote State by raising the REN line and then addressing the device as a listener.

REMOTE WITH LOCKOUT STATE (RWLS)

In RWLS, the controller has complete control over the GPD550A's operating parameters, including certain display controls (CURSOR, RT/EXT/AVGR) that are front panel controllable in the Remote State. SET REF is not included with the GPIB control-lable switches and is always under front panel control since it effects only the cursor LED display. Otherwise, the GPD550A's operation is identical to the Remote State (REMS).

3.8 GPIB INTERFACE MESSAGES

This section explains the standard interface messages the controller uses to manage the bus. Message abbreviations used are from ANSI/IEEE Std 488-1978.

REMOTE ENABLE (REN)

When the Remote Enable (REN) line is raised and the GPD550A is addressed as a listener, the GPD550A is placed in either the Remote State (REMS) or the Remote With Local Lockout State (RWLS). When in either state, the REM bar LED is illuminated.

GO TO LOCAL (GTL)

Devices that are already addressed as a listener respond to the Go To Local (GTL) message by assuming local front panel control and going to the Local State (LOCS).

LOCAL LOCKOUT (LLO)

The Local Lockout (LLO) message places all the devices on the bus which have local lockout capability in either the Local With Lockout State (LWLS) or the Remote With Lockout State (RWLS).

MY LISTEN AND MY TALK ADDRESSES (MLA AND MTA)

The Talk/Listen interface function provides a device with the capability to send and receive device dependent data over the GPIB interface. The primary Talk/Listen address is a unique numeric identifier from 0 to 31 for each of the devices of the interface bus. For information on setting the GPD550A's primary address, see Section 3.2.

UNLISTEN (UNL) AND UNTALK (UNT)

When the Unlisten (UNL) message is received, the GPD550A's listen function is placed in an idle (unaddressed) state. In this state, the GPD550A cannot accept programming messages over the GPIB and the LSTN LED is off. Likewise, the Untalk (UNT) message places the talk function in an idle state. In this state, the GPD550A cannot transmit data via the GPIB and its Talk LED is off.

INTERFACE CLEAR (IFC)

When the Interface Clear (IFC) line is raised, all bus activity is unconditionally terminated and GPD550A Talk and Listen functions are placed in an idle state and the front panel LED indicators are turned off. The Return to Local bit in the Serial Poll byte clear will be set upon an Interface Clear.

DEVICE CLEAR (DCL)

When the Device Clear (DCL) message is sent, all the devices on the interface bus which have Device Clear capability will respond by clearing themselves, regardless of their individual operating state. Device Clear is device-defined in terms of capability and functionality. The GPD550A performs a power-on reset for Device Clear.

SELECTED DEVICE CLEAR (SDC)

This message performs the same function as Device Clear; however, only devices that have been addressed to listen respond to Selected Device Clear.

SERIAL POLL ENABLE AND DISABLE (SPE AND SPD)

The Serial Poll Enable (SPE) message causes all the devices on the interface bus which have Service Request capability to send their serial poll status byte when they are addressed to talk. The Serial Poll Disable (SPD) message switches all the devices on the interface bus back to its normal operation, the Serial Poll idle state. See the next section for an explanation of the Serial Poll Status Byte.

3.9 SERIAL POLL STATUS BYTE

The Serial Poll Status Byte is the means by which the controller can quickly determine the status of each device on the bus. Included in the Serial Poll is the capability to interrupt the controller by raising the Service Request (SRQ) line on the GPIB. The SRQ provides the means of indicating that an even (either a change in status or an error) has just occurred. To service a request, the controller performs a Serial Poll, addresses the device as a talker, then reads its Serial Poll Status Byte, which indicates the type of event that occurred.

The following defines the GPD550A's implementation of the Serial Poll Byte, with each bit functioning as a processing status or error flag.

In addition to the Serial Poll Byte, the GPD550A supplies the controller with access to a Service Request Mask. This mask mirrors the Serial Poll Byte's bit by bit definition, but is used to indicate which GPD550A flag will generate an SRQ. This gives the controller the ability to monitor only the unmasked conditions and ignore those which are of no interest. See Section 3.5 for more information on reading and writing of the Service Request Mask.

SERIAL POLL BYTE

Bit 7 Not used.

Bit 6 SRQ. Set if any of the condition bits in the Service Request Mask is set (unmasked) and at least one of the corresponding conditions of the Serial Poll Byte is true. Reset by the Serial Poll is all the unmasked conditions are false or if all the Serial Poll conditions are masked.

Bit 5 Linear Average Complete. Set by the GPD550A averager when it has completed averaging the last ensemble of the selected NUMBER OF AVERAGES when RECYCLE is off. Changing from PEAK or EXP averaging mode to LIN mode while the averager is running will also force a Linear Average Complete. This bit is cleared by an averager reset or by the Serial Poll if this Service Request Mask bit is set.

Bit 4 CF Error. Set if the Center Frequency selected is out of the allowable limits of Center Frequency/2 to 12 MHz (Center Frequency/2). Reset by the Serial Poll or if a new Center Frequency is selected within the allowable limits. This bit is set when the CF indicator on the front panel is on, and cleared otherwise. For more information regarding the CF indicator, refer to Section 2.3.4.

Bit 3 Overload. Set upon signal overload as indicated by the GPD550A front panel OVR (overload) LED. If the corresponding bit is set in the Serial Request Mask, a Serial Poll must be done in order to clear Bit 3, otherwise it is cleared once the overload condition is no longer true.

Bit 2 Underload. Set upon signal underload as indicated by the GPD550A front panel UNDR (underload) LED. If the corresponding bit is set in the Serial Request Mask, a Serial Poll must be done in order to clear bit 2, otherwise it is cleared once the underload condition is no longer true.

Bit 1 GPIB Command Error. Set if the GPD550A receives an illegal GPIB status change or query, or upon the indicated error conditions listed in Section 3.6. This bit is not cleared by a Serial Poll, but by the ER? query, which sends the contents of the invalid command buffer, then resets the buffer and clears Bit 1.

Bit 0 Return to Local. Set upon an Interface Clear. This bit is cleared by the Serial Poll.

SECTION 4

SPECTRUM DATA TRANSFER

4.1 SPECTRUM DATA FORMAT

4.1.1 12-BIT DATA

The GPD550A's 12-bit data is formatted into two bytes, each representing one data point, with the least significant nibble first. Therefore, the number of bytes transferred over the GPIB in a block of spectral data depends upon the current transform size. This number is given by the following formula:

number of bytes = number of bins displays x 2

= (RESOLUTION) x 2

where RESOLUTION is the number of points returned following a transform size query (RE?).

	Bit 3	Bit 2	Bit 1	Bit 0				
dB Weight	.375	.188	.092	.047				

Bit 11	Bit 10	Bit 9	Bit8	Bit 11	Bit 10	Bit 9	Bit 8
96	48	24	12	6	3	1.5	.75

Full Scale Value 0 dB at Input 0 dBm

1	1	0	1	0	1	1	0	1	0	0	1	0	0	0	0

Note: The four unused bits in the least significant byte are read as zero.

4.1.2 8-BIT DATA

The 8-bit data format is a reduced range version of the 12-bit format. Each byte transferred represents one data point. The number of bytes transferred over the GPIB in a block of spectral data depends upon the current transform size. This number is given by the following formula:

$$\text{number of bytes} = \text{number of bins displayed} = \text{RESOLUTION}$$

where RESOLUTION is the number of points following a RESOLUTION query (RE?).

The GPD550A 8-bit spectral data ranges from 0 dB to -63.75 dB in 0.25 dB steps. To convert the 8-bit magnitude squared data (DATA) to dB, use the following formula:

$$dB = (DATA - 255)/4.0 - gain$$

Thus, a data byte of 255 equals 0 dB and 0 equals -63.75 dB, assuming the gain is zero. The 8-bit data is equivalent to within $\pm$0.125 dB of the original 12-bit data point.

4.2 DATA TRANSFER TIMING

Given the ability of the GPD550A to read spectral data over the GPIB, two questions arise, when is data available to transfer, and how long does the actual transfer take.

The latter question is easily answered by stating that the maximum data transfer rate attainable, dictated by the DMA hardware, is 12.5 micro-seconds per byte. The actual transfer rate per spectrum however, is dependent upon the maximum rate obtainable by the controller and upon the time required to set up each data transfer by sending the appropriate ASCII commands over the bus. As an example of the order of magnitude that can be expected,an IBM AT Compatible 12 MHz using a National Instruments Rev D GPIB card transfers an 800-point spectrum in approximately 26 ms. This time includes sending the "OS LR" command to set up the transfer.

The question of when data is available for transfer is rather more complicated to answer. Data is always available to be read, however, it is not true that each output spectrum represents fully processed input data. The time required by the FFT to transform a completely new set of input time domain data to the frequency domain is given by Memory Period/2 (MP/2).

The controller must also be aware that spectral data read over the GPIB when Hold is disabled may consist of different sets of input data processed during different FFT cycles. To read data processed from the same set of input data, put the GPD550A in Hold, wait for the input data to stabilize, and then read spectral data through the GPIB.

APPENDIX A
GPIB COMMAND REFERENCE

HEADER	ARGUMENT	MESSAGE RETRIEVED
AMode	Lin Expo Peak	none
AMode?	none	L E P
AUxdisplay	Ext (Both) Avgr RT	none
AUxdisplay?	none	E A W
AVgr	Reset Cycle Go Stop	none
AVgr?	none	R G S L
CFrequency	positive integer or real number (+ suffix)	none
CFrequency?	none	positive integer or real number
CUrsor	positive integer	none
CUrsor?	none	positive integer
DB?	none	real number
ERror?	none	character string
FRont	#<32 bytes block data	none
FRont?	none	<32 bytes block data>

HEADER	ARGUMENT	MESSAGE RETRIEVED
HOld	Enable Disable	none
HOld?		E D
INput	integer (+ suffix)	none
INput?	none	integer
NUmber	positive integer	none
NUmber?		positive integer
OPerate/Test	Operate Test	none
OPerate/Test?	none	O T
OSpectrum	LA LR SA SR	<spectrum data> <spectrum data> <spectrum data> <spectrum data>
RAnge	positive integer or real (+ suffix)	none
RAnge?	none	positive integer or real (+ suffix)
REsolution	positive integer	none
REsolution?	none	positive integer
SMask	positive integer	none
SMask?	none	positive integer
TEst	"<5 alphanumeric bytes>"	none
TEst?	none	5 alphanumeric characters
WHold	Enable Disable	none
WHold?	none	E D

APPENDIX B

FR COMMAND FORMAT

The following specification defines the format of the "FR" command argument. The table functions as a system communications bus, and is designed as a table of bytes, each byte coding some portion of the system's operating parameters.

This table can be read from or written to by a controller over the GPIB. Ideally, a controller could quickly change all of the GPD550A's operating parameters by writing one CPU Interface table over the GPIB using the "FR" command. However, changes are limited by the following rules:

1. Changes to the Center Frequency by changing the two center frequency values in addresses 4 to 7 and 10 to 17 is not allowed. Selecting a Center Frequency over the GPIB may be done with the "CF" command only.

2. Status information contained in the CPU interface, specifically in address 1, bit 6 and address 9, is a reflection of internal operating parameters and cannot be controlled by simply changing the encoded bits.

3. All other front panel controls: Input, Test/Operate, Hold, Resolution, Range, AUX Display, Number of Averages and Averaging mode may be controlled by substituting the desired encoded settings to the corresponding addresses.

The controller must be aware that there is no error checking done on the CPU Interface written to the GPD550A, and incorrect data could possibly disrupt the entire operation of the GPD550A; therefore, it is emphasized that this command must be used with care.

The following table defines the function and coding of the interface bytes:

NOTES:

- Table size is fixed at 32 bytes.
- All Addresses and Codes are hexadecimal.
- All unused Addresses are transferred with a value of 00.
- Bits are labeled from 0 (LSB) to 7 (MSB).
- If no specific bits are given for a code, the complete byte is used.
- All unused bits are transmitted as 0.

ADDRESS: 00

NAME: INPUT (dBm)

FUNCTION: Codes the Gain switches. Settings are coded as follows:

Bits 0 to 3: INPUT (dBm)

Code	Meaning
0	-30 (dBm)
1	-25
2	-20
3	-15
4	-10
5	- 5
6	0
7	+ 5
8	+10
9	+15
A	+20

Bits 4 to 7: Unused

ADDRESS: 01

NAME: MISCELLANEOUS

FUNCTION:

Bit 0: 1 = Test
0 = Operate

Bit 1: 1 = Hold on
0 = Hold off

Bit 2-3: Reserved

Bit 4: 1 = WF Hold On
0 = WF Hold Off

Bit 5: Unused

Bit 6: 1 = Remote on and Local Lockout on
0 = Remote off or Local Lockout off

Bit 7: Unused

ADDRESS: 02

NAME: RESOLUTION

FUNCTION: This byte codes the Resolution switch as follows:

Code	Meaning
00	100
01	200
02	400
03	800
04	1600
05	3200

ADDRESS: 03

NAME: RANGE

FUNCTION: This byte codes the Range (KHz) switch as follows:

Bits 0 to 3: Power of 2 Range Divisor

Bits 4 to 5: Base Range

Code	Meaning	
00	4.8 MHz	*(0B,0C,0D)
01	8 MHz	*(1D,1E,1F)
02	12 MHz	*(2D,2E,2F)

*Indicates unused Range Divisors

For example: 46.875 KHz = 28 (hex) = (12 MHz)2^8 **

** '^' is the exponential operator.

For a listing of all the range codes, refer to Appendix C.

ADDRESS: 04

NAME: CENTER FREQUENCY 0

FUNCTION: This byte is the least significant byte of the 32-bit integer valued Center Frequency. This byte and the three following are valid only if bit 2 and bit 3, address 1 of this table, is zero.

ADDRESS: 05

NAME: CENTER FREQUENCY 1

FUNCTION: This byte is the second significant byte of the 32-bit integer valued Center Frequency.

ADDRESS: 06

NAME: CENTER FREQUENCY 2

FUNCTION: This byte is the third significant byte of the 32-bit integer valued Center Frequency.

ADDRESS: 07

NAME: CENTER FREQUENCY 3

FUNCTION: This byte is the most significant byte of the 32-bit integer valued Center Frequency.

ADDRESS: 08

NAME: DISPLAY FORMAT

FUNCTION: This byte codes the Display formatting switches as follows:

Bits 0 to 1: AUX Display

Code	Meaning
00	BOTH
01	WB
03	AVGR

Bit 2: CRT Cursor - valid only when AUX Display is BOTH.

Code	Meaning
0	RT trace
1	AVGR trace

Bits 3 to 7: Unused.

ADDRESS: 09

NAME: LED INDICATORS

FUNCTION: This byte codes the front panel LED indicator values as follows:

Bit 0:	Center Frequency Error	0 = OFF, 1 = ON
Bit 1:	(GPIB) Remote Status	0 = OFF, 1 = ON
Bit 2:	(GPIB) Talk	0 = OFF, 1 = ON
Bit 3:	(GPIB) Listen	0 = OFF, 1 = ON
Bit 4:	(GPIB) SRQ	0 = OFF, 1 = ON
Bit 5 to 7:	Unused	

ADDRESS: 0A

NAME: MEMORY PERIOD SETTINGS

FUNCTION:

Bit 0: 0 = Unit 1 not up (power up mode)
1 = Unit 1 operating normally

Bit 1 to 3: 550 Version status (when shipped, this is always set to 10)

00 = 550
01 = 550-1 version
10 = 550A version

Bit 4 to 5: 00 = MP/2
01 = MP/4
10 = Free Run

Bit 6 to 7: Unused

ADDRESS: 0B

NAME: AVERAGER

FUNCTION: This byte codes the Averager Control switches as follows:

Bits 0 to 3: Number of Averages

Code	Meaning
00	1
01	2
02	4
03	8
04	16
05	32
06	64
07	128
08	256
09	512

Bit 4: 0 = Averager Recycle Off
1 = Averager Recycle On

Bit 5: Unused
Bits 7 and 8: Averaging Method

Code	Meaning
00	EXPONENTIAL
01	PEAK
02	LINEAR

ADDRESS: 0C

NAME: EXTENDED RANGES (used for 550-1 version)

FUNCTION: Bits 0 to 7: Reserved

ADDRESS: 0D to 0F

FUNCTION: Unused

ADDRESS: 10 TO 17

NAME: CENTER FREQUENCY, UNPACKED BCD

FUNCTION: Center Frequency in unpacked BCD, least significant digit (10) to most significant digit (17).

ADDRESS: 18 TO 1F

FUNCTION: Unused

APPENDIX C

CPU INTERFACE RANGE CODES

The following table defines the available GPD550A ranges and corresponding range code used by the CPU interface. The range codes are listed in hexadecimal.

4.8 MHz - 0	8 MHz - 10 *	12 MHz - 20 *
2.4 MHz - 1	4 MHz - 11 *	6 MHz - 21 *
1.2 MHz - 2	2 MHz - 12 *	3 MHz - 22 *
600 KHz - 3	1 MHz - 13 *	1.5 MHz - 23
300 KHz - 4	500 KHz - 14 *	750 KHz - 24
150 KHz - 5	250 KHz - 15 *	375 KHz - 25
75 KHz - 6	125 KHz - 16 *	188 KHz - 26
37.5 KHz - 7	62.5 KHz - 17 *	93.8 KHz - 27
18.8 KHz - 8	31.2 KHz - 18 *	46.9 KHz - 28
9.38 KHz - 9	15.6 KHz - 19 *	23.4 KHz - 29
4.69 KHz - A	7.8 KHz - 1A *	11.7 KHz - 2A
	3.9 KHz - 1B *	5.86 KHz - 2B
	1.95 KHz - 1C *	2.93 KHz - 2C

*Front panel range.

NOTE: The lower range values are rounded, for exact values, refer to Range Selector description in Section 2.1.2.

APPENDIX D

GPIB SPEED CONSIDERATIONS

A crucial factor in programming any device over the GPIB is device-dependent speed limitations. These limits encompass such timing factors as command response time, system state change time, data transfer time, and general processing time.

The following table provides information regarding the processing time required to send a state change command, update the internal front panel in the GPD550A and see the change reflected by querying the GPD550A. The time given includes sending the command and query, and reading the query response over the interface bus.

Note that these are worst-case times; depending upon the operating state of the GPD550A, the response time could vary significantly. Additional time may also be required for the changes to effect the spectral data.

COMMAND	RESPONSE TIME
AMode	.009 sec
AUxdisplay	.009 sec
AVgr	.056 sec
CFrequency	.139 sec
CUrsor	.149 sec
HOld	.009 sec
INput	.019 sec
NUmber	.019 sec
OPerate/Test	.010 sec
RAnge	.039 sec
REsolution	.137 sec

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